THE GERMPLASM RELEASE OF B0718-3 AND B0767-2: TWO LATE BLIGHT RESISTANT POTATO CLONES

R.W. Goth[1] and K.G. Haynes[2]

Abstract

Two potato breeding selections were released by the United States Department of Agriculture, Agricultural Research Service on November 14, 1996, as germplasm that is highly resistant to current populations of *Phytophthora infestans* (Mont.) deBary, the causal organism of potato late blight : B0718-3 and B0767-2. These two clones have been evaluated for their reaction to *P. infestans* in replicated plots at Presque Isle, Maine since 1990. B0718-3 is a netted white-skinned selection with good yields but low specific gravity. It is both male and female fertile and crosses readily with tetraploid Tuberosum. B0767-2 is a russet-skinned selection that is low yielding and low in specific gravity. It has not been successfully crossed; however, it may have some potential use in somatic hybridizations. Neither B0718-3 nor B0767-2 process into acceptable colored chips. Genetic material of this release has been deposited in the National Plant Germplasm System where it is available for research purposes, including development and commercialization of new cultivars.

Compendio

El 14 de noviembre de 1996, el Servicio de Investigación Agrícola del Departamento de Agricultura de los Estados Unidos liberó dos selecciones mejoradas de papa (B0718-3 Y B077-2) como germoplasma que es altamente resistente a las poblaciones actuales de *Phytophthora infestans* (Mont.) de Bary, el organismo causal del tizón tardío de la papa. Estos dos clones han sido evaluados para su reacción a P. *infestans* en parcelas replicadas en Presque Isle, Maine, desde 1990. B0718-3 es una selección de piel blanca con buen rendimiento pero con baja gravedad específica. Es fértil tanto para el macho como para la hembra y se cruza facilmente con Tuberosum tetraploide. B0767-2 es una selección de piel rojiza de bajo rendimiento y baja gravedad específica. No ha sido cruzada con éxito; sin embargo, tiene cierto potencial en hibridaciones somáticas. Ni B0718-3 ni B0767-2 se procesan en hojuelas de colores aceptables. El material genético de esta liberación ha sido depositado en el Sistema Nacional de Germoplasma de Plantas donde se encuentra disponible para fines de investigación, incluyendo el desarrollo y comercialización de nuevos cultivares.

Pedigrees of B0718-3 and B0767-2

The pedigrees of B0718-3 and B0767-2 are presented in Figures 1 and 2,

[1]Research Plant Pathologist.
[2]Research Plant Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Plant Sciences Institute, Vegetable Laboratory, Beltsville, Maryland 20705.
Accepted for publication June 12, 1997.
ADDITIONAL KEY WORDS: *Phytophthora infestans*, late blight resistant germplasm.

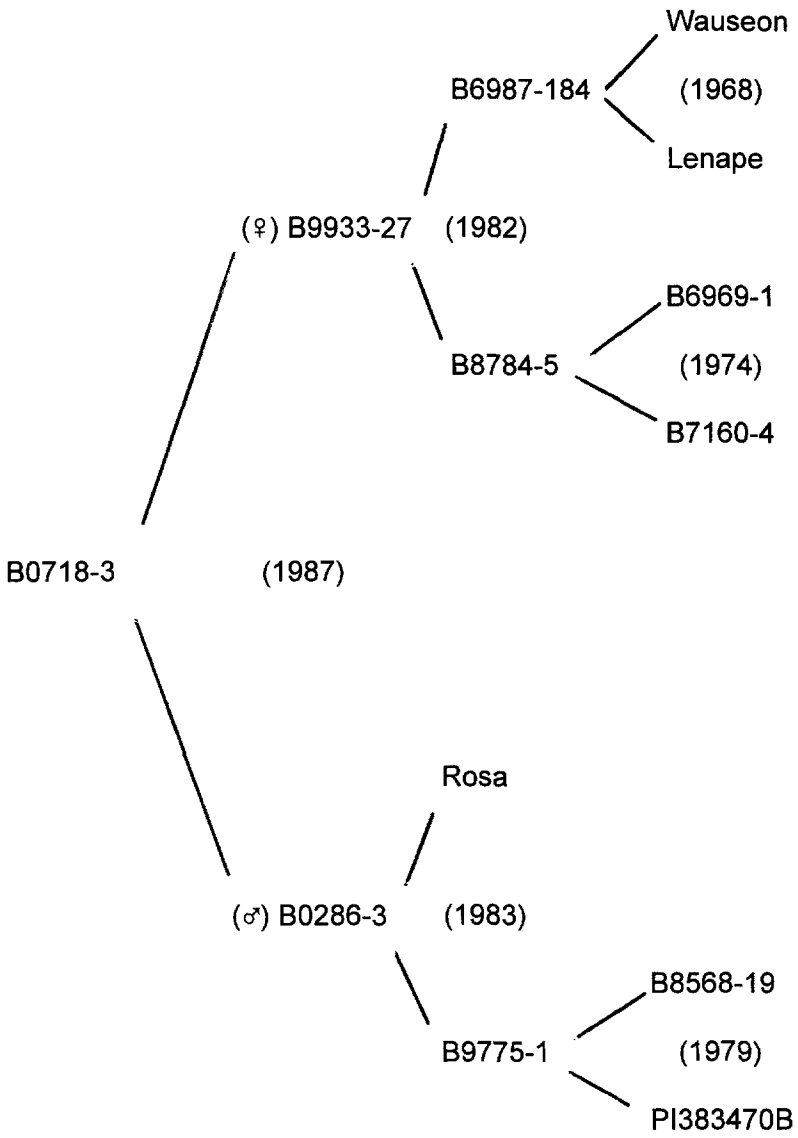

FIG. 1. Pedigree of B0718-3.

respectively. The late blight resistance in these clones was derived from PI383470B, which was a great-grandparent for both clones, although other parental material may have contributed some minor gene resistance. However, the other parental breeding clones were discarded from the breeding program before the appearance of the A2 mating type of *Phytophthora infestans*, and thus, could not be tested against these new populations.

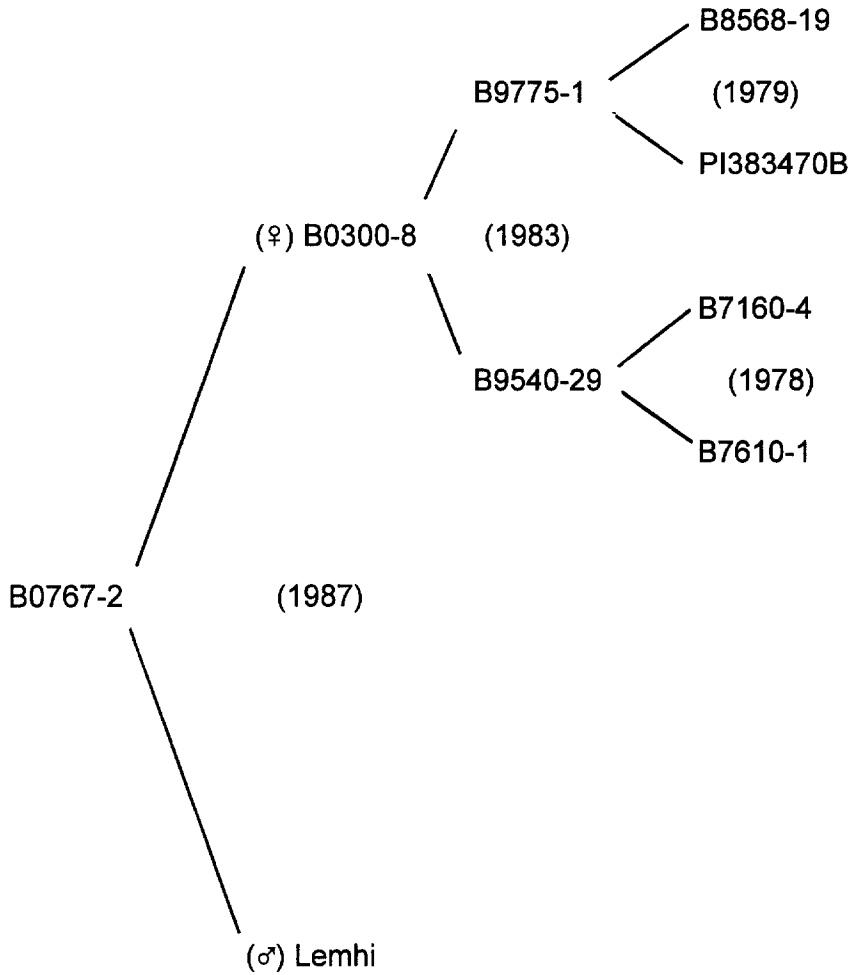

FIG. 2. Pedigree of B0767-2.

Developmental History

Seedlings from eight plant introductions that reportedly had late blight resistance were screened for late blight in the greenhouses at Beltsville, MD in 1976, 1977 and 1978. Tolerance to late blight was identified in one selection, PI383470B. PI383470B was an introduction of *S. tuberosum* L. from India clone 1033, that was originally selected for late blight resistance in Mexico by the International Potato Center (USDA, 1975).

In 1979 eight segregating seedling families from crosses with PI383470B were planted on Chapman Farm, Presque Isle, Maine for seed increase and selection. At harvest, 167 selections were selected for tuber type. These 167 selections were evaluated for late blight in the greenhouses at Beltsville, MD in 1980 and 1981,

and at Aroostook State Farm, Presque Isle, ME in 1980. In 1982, 26 of the most tolerant selections were re-evaluated in the late blight plot on Aroostook State Farm. Only two showed some resistance to late blight, B9775-1 and B9775-17.

Thirteen segregating seedling families involving crosses with these two late blight resistant selections were transplanted to the late blight disease plot on Aroostook State Farm in 1983. In all, a total of 1,321 seedlings were transplanted and a total of 168 showed some tolerance to late blight and were saved for retesting in 1984. Of these 168, only 34 survived the late blight test in 1984, and only 19 survived the late blight test in 1985.

Twenty-eight segregating seedling families involving crosses with five of the late blight resistant selections that survived the 1985 test were planted on Chapman Farm in 1987 and 212 out of 4,680 seedlings were saved based on tuber type. These were increased in 1988. In 1989 these selections were screened for late blight resistance on Aroostook State Farm. Replicated evaluations began in 1990 as described below.

The two late blight resistant selections being released are from this later cycle of selection. This resistance has been incorporated into one fairly smooth netted white-skinned and one russet-skinned selection. The developmental history suggests that resistance to late blight is inherited in a fairly complex manner. Therefore, these selections have been released to provide germplasm that may be used to develop late blight resistant cultivars.

Methods of Evaluations

Field Trials—Seed tubers of cultivars and breeding selections were propagated the previous year in seed plots at Chapman Farm, Presque Isle, ME on a Caribou silt loam soil. All plants used were derived from virus tested seed stocks. The number of selections tested varied from year to year as susceptible selections were discarded.

Following storage at 5-12 C seed was cut, warmed and planted in a Caribou silt loam soil on Aroostook State Farm, Presque Isle, ME from 1990-1994 in a randomized complete block design with two replications. Plants were spaced 30 cm within the row on rows 90 cm apart. Planting dates, number of plants per replication, and date plants were evaluated for late blight are given in Table 1.

TABLE 1.—*Planting date, number of hills planted per replication and date plants were evaluated for late blight in the late blight disease trial on Aroostook State Farm, Presque Isle, Maine from 1990 to 1994.*

Year	Planting Date	Hills/Replication	Evaluation Date
1990	June 12	2	September 24
1991	June 11	8	September 5, 9
1992	May 18	8	September 20
1993	May 19	4	September 5, 6
1994	June 13	4	August 31

Guard rows and every third row in the trial were planted with the late blight susceptible cultivar Green Mountain. The plot was fertilized with 14-14-14 NPK at 1100 kgs/ha. Weeds and grasses were controlled with the herbicides Lorox (linuron) 0.6 kg a.i./ha and Poast (sethoxydim) 0.3 kg a.i./ha. Irrigation was not available and except that fungicides were not applied, standard crop management practices were followed.

From 1991-1994, vines were killed with a rotabeater and tubers harvested with a single row digger. Plot yield was recorded and specific gravity was determined by the weight in air and weight in water method. Five tubers from each plot were stored at 10 C and processed into potato chips in January.

Inoculum—For the initial late blight field test in 1990, we used isolates of race 0, 1, and race 1, 2, 3, 4 of *P. infestans* from our stock collection. Each subsequent year, the new isolates that were derived from infected leaves, stems and tubers in the previous year's late blight trial plot were included in the inoculum. Throughout this study, we maintained the stock cultures on sterilized corn (Goth, 1981) in incubators in the dark at 15 C. In 1994, we determined the mating type of the isolates on rye, V8 juice, and clarified V8 juice agar (Deahl *et al.*, 1991). Isozyme characterizations were made for each isolate (Goodwin *et al.*, 1994a; Goodwin *et al.*, 1994b). A set of single R-gene differential potato genotypes that we obtained from the USDA Potato Introduction Station at Sturgeon Bay, WI was used to differentiate the physiological races of the isolates. The mating type, physiological race distinction and genotype of the isolates present in the field in 1994 are given in Table 2.

TABLE 2.—*Mating type, physiological race and genotype of some* Phytophthora infestans *isolates recovered from plots used to evaluate clones B0718-3 and B0767-2 in 1994.*

ISOLATE	MATING TYPE[a]	Physiological Race[b]	Pathogen Genotype
93-1	A_2	(R1) (R1,2) (R1,3) (R1,4) (R1,2,3) (R2,3) (R7)	US 8
93-2	A_2	(R1) (R2) (R4) (R5) (R1,4) (R1,2) (R1,3) (R1,4) (R1,2,3) (R2,3) (R7) (R9)	US 8
93-4	A_2	(R5) (R9) (R1,2) (R1,3) (R2,3) (R1,2,3)	US 8
94-1	A_2	(R1) (R2) (R4) (R5) (R7) (R9) (R1,4) (R1,2) (R1,3) (R1,2,3) (R2,3)	US 8
94-2	A_1	(R2) (R1,2) (R1,3) (R1,4) (R7) (R9)	US 7
R1234	A_1	(R1,2,3,4)	US 6
Race 0	A_1	(R0)	US 1

[a]Presence of oospores when mated with known A_1 and A_2 test lines.

[b]Physiological race was determined by reaction on detached leaves and plants of R gene late blight differential plant genotypes obtained from USDA Potato Introduction Station at Sturgeon Bay WI.

Disease Assessments—Mid-to-late-July, approximately four to six weeks after planting, we inoculated the Green Mountain border and spreader rows with a suspension containing a mixture of 1 x 10^5/ml zoospores of each *P. infestans* test isolate. The disease response of each plant was assessed visually immediately prior to harvest. Plants were rated using a modification of the British Mycological Society Rating, as presented by James (1971), in which 1= no disease observed; 2= plants blighted, no more than 1 or 2 lesions per plant; 3= up to 10 lesions per plant, or general light infections; 4= about 50 lesions per plant, up to 1 in 10 leaflets infected; 5= nearly every leaflet infected, but plants retain normal form, plants appear green; 6= every plant affected and about 50% of the leaf area is destroyed, plants appear green but flecked with brown; 7= about 75% of the leaf area is destroyed, plants appear light brown; 8= plants nearly defoliated, stems are green; 9= all leaves dead, stems dead or dying.

Characteristics of B0718-3

Late Blight Reaction: In field tests conducted from 1990 to 1994 in Presque Isle, Maine, the amount of defoliation due to late blight in B0718-3 was generally equal to the amount of defoliation in PI383470B, the late blight resistant great-grandparent, and generally significantly less than the amount of defoliation observed in Atzimba, a Mexican cultivar with late blight resistance (Table 3).

Plants: late maturity. The vine is medium-large with good row cover. Vines are upright at blossom stage. Stems are medium-green with slight pubescence, no pigmentation and slightly swollen nodes. *Wings:* small inconspicuous, slightly waved, single. *Stipules:* medium size, spreading. *Leaves:* dark green, rough, slight inconspicuous pubescence, closed type. *Terminal leaflets:* medium size, most are symmetrical and lobate. *Primary leaflets*: medium size, lobate, mostly symmetrical, often four pairs. *Secondary leaflets:* numerous, small but prominent. *Tertiary leaflets:* numerous, very small, overlapping. *Midribs:* light green with very slight pubescence. *Petioles:* medium green, slight pubescence.

Flowers: moderate number, on a peduncle arising from the main stem with a cluster at or just under plant crown. *Peduncle:* medium length, light green, pubescent. *Buds:* dark pink with cream tips. *Calyx*: 11 mm when corolla is fully open, awl shaped, slightly pubescent. *Corolla*: 28 mm diameter, light purple, with cream tips, flat when fully open. *Anthers*: yellow-orange. *Pollen:* abundant. *Fertility*: both male and female fertile.

Tubers: netted white-skinned, round to oblong, shallow eyes , white flesh, low specific gravity (Fig. 3). Average glycoalkaloid content in 1996 was 10.26 mg/100 g fresh weight, as compared to Atlantic at 10.13 mg/100 g fresh weight.

TABLE 3.—*Reactions of B0718-3, B0767-2, Atzimba, Kennebec and PI383470B to diverse isolates of* Phytophthora infestans[a] *(top line), yield per plant in kg (second line), average specific gravity (third line) and chip color[b] (fourth line).*

	1990	1991	1992	1993	1994
B0718-3	1.5	2.5	4.1	4.5	3.5
	–	1.7	1.3	0.5	1.0
	–	1.063	1.079	–	1.068
	–	9.9	10.0	9.5	9.5
B0767-2	2.5	3.5	3.4	4.0	3.0
	–	0.6	1.8	0.6	0.9
	–	1.066	1.089	–	1.071
	–	9.6	9.6	9.5	9.8
Atzimba	5.9	6.0	9.0	5.5	6.0
	–	0.3	0.8	0.5	0.8
	–	1.059	1.072	–	1.073
	–	8.8	9.0	9.7	8.4
Kennebec	8.2	7.3	9.0	5.0	8.8
	–	0.7	1.5	0.6	0.8
	–	1.061	1.071	–	1.074
	–	7.3	8.0	8.7	7.4
PI383470B	3.5	2.0	4.2	7.5	3.3
	–	1.6	2.2	1.2	1.1
	–	1.063	1.071	–	1.066
	–	9.5	9.5	9.0	8.6
LSD (0.05)	–	2.0	2.2	5.3	1.4
	–	0.4	0.4	0.3	1.3
	–	0.007	0.007	–	0.007
	–	0.7	1.0	1.9	0.8

[a]Rating scale used by James (1971).
[b]Chip color is rated on a 1-10 scale with 1 = white to 10 = black; 1-7 is considered acceptable.

Characteristics of B0767-2

Late Blight Reaction: In field tests conducted from 1990 to 1994 in Presque Isle, Maine, the amount of defoliation due to late blight in B0767-2 was generally equal to the amount of defoliation in PI383470B, the late blight resistant great- grandparent, and generally significantly less than the amount of defoliation observed in Atzimba, a Mexican cultivar with late blight resistance (Table 3).

FIG. 3. Tubers of B0718-3.

Plants: very late maturity. The vine is very large with good row cover. Vines are upright at blossom stage. Stems are medium-green with slight pubescence, very light pigmentation at the second node and its base, nodes slightly swollen. *Wings:* medium, very waved, single. *Stipules*: medium size, partial clasping. *Leaves*: medium green, pubescent, elongate, closed type. *Terminal leaflet:* medium size, most are symmetrical and lobate. *Primary leaflets:* medium size, lobate, often four or more pairs, short lobes on right of midrib. *Secondary leaflets:* numerous, overlapping. *Tertiary leaflets*: numerous, small, clasping. *Midribs:* medium-green, slightly pubescent. *Petioles*: medium-green, slightly pubescent, slight pigmentation on leaves.

Flowers: very abundant, inflorescence borne on long peduncle above the foliage. Peduncle: long, pubescent, light green. *Buds:* dark purple with cream tips. *Calyx*: 10 mm when corolla is fully open, awl shaped, medium green, pubescent. *Corolla*: 30 mm diameter, dark purple, with cream tips, ruffled. *Anthers*: orange. *Pollen*: moderate. *Fertility*: not fertile.

Tubers: russet-skinned, oblong, shallow eyes, creamy white flesh, low specific gravity (Fig. 4). Average glycoalkaloid content in 1996 was 3.86 mg/100 g fresh weight, as compared to Russet Burbank at 7.88 mg/100 g fresh weight.

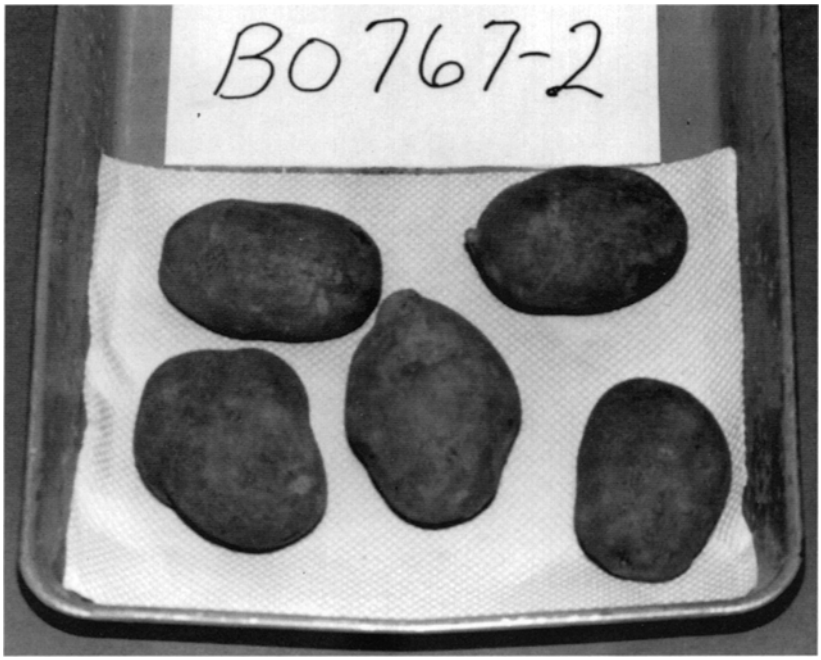

FIG. 4. Tubers of B0767-2.

Availability

B0718-3 and B0767-2 are available as *in vitro* plantlets from K.G. Haynes, USDA/ARS. Genetic material of this release has also been deposited in the National Plant Germplasm System where it is available for research purposes, including development and commercialization of new cultivars.

Literature Cited

Deahl, K.L., R.W. Goth, R. Young, S.L. Sinden, and M.E. Gallegly. 1991. Occurrence of A2 mating type of *Phytophthora infestans* in potato fields in the United States and Canada. Am Potato J 68:717-726.

Goodwin, S.B. B.A. Cohen, and W.E. Fry. 1994. Panglobal distribution of a single clonal lineage of the Irish potato famine fungus. Proc Natl Acad Sci USA 91:11591-11595.

Goodwin, S.B., B.A. Cohen, K.L. Deahl, and W.E. Fry. 1994. Migration from northern Mexico as the probable cause of recent genetic changes in populations of *Phytophthora infestans* in the United states and Canada. Phytopathology 84:553-558.

Goth, R.W. 1981. An efficient technique for prolonged storage of *Phytophthora infestans.* Am Potato J 58:257-260.

James, C. 1971. A manual of assessment keys for plant diseases. Can Dep Agric Publ 1458:32-33.

United States Department of Agriculture. 1975. Plant Inventory No. 181. Washington, D.C. p. 181.